

WASHINGTON

# SCIENCE TRENDS

HIGHLIGHTS

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## Space Electronics & Auxiliary Power

Jet Propulsion Laboratory (JPL), in a study prepared for the National Aeronautics and Space Administration (NASA), concludes that conventional auxiliary power systems such as batteries and fuel cells can play no major role in lunar and interplanetary probes. For operating times beyond 50 hours, JPL declares, weight becomes excessively heavy in comparison with solar cells and nuclear energy sources.

### Here is a summary of major findings and recommendations:

\* Lunar Space Probes: JPL points out that the average power required for the lunar probes now being planned for the next few years varies from 2.5 to 2000 watts. In a typical mission, a power pulse of 200 watts would be required for three hours after take-off for lunar acquisition, and again at moon intercept for terminal guidance. Nickel-cadmium or silver-zinc batteries could provide these short-term power pulses. However, an additional 20 watts would be required for five hours to transmit a lunar picture to earth. Solar cells and radioisotope thermionic diodes are being evaluated for these tasks. In a typical payload, one transistor-magnetic static inverter would provide 400-cps power, both square wave and sine wave, at 26 volts rms, as well as 6.3 volts dc. to power both the instrumentation and the guidance equipment.

\* Planetary Probes: JPL foresees an average power requirement of 100 to 2000 watts for Mars and other planetary probes. As in lunar missions, power pulses would be provided by electrochemical batteries recharged during flight. One static inverter, it is said, would provide all the regulated ac and dc power in order to achieve simplicity, reliability and minimum weight.

Studies by JPL indicate that radioisotope thermionic diodes and thermoelectric elements would be preferred for these longer missions. Mars, as an example, is roughly 52 percent farther from the sun than is the earth and the power received by radiation from the sun for solar cell operation would be considerably reduced. If radioisotopes are used, shielding must be provided so as not to interfere with cosmic-ray and gamma-ray experiments. It is believed that this problem can be solved satisfactorily and that these devices may weigh less than solar cells, while they would be less likely to be damaged by micrometeorite showers. For flights beyond Mars, it is believed, only nuclear energy sources will prove feasible since the solar-energy level decreases as the square of the distance from the sun.

## Energy Sources and Conversion Controls

- \* Solar Power: Space Payloads proposed by JPL to NASA call for silicon photo-voltaic cell assemblies consisting basically of a multiple array of individual cells made from a large single crystal of silicon. For this purpose, hyperpure silicon is melted in a controlled atmosphere at about 2000° F. and a minute quantity of pure arsenic is added. It is planned to "dope" the sliced silicon crystal by boron diffusion and it is predicted that the average efficiency of a solar cell package incorporating a diode will be on the order of 7.5 percent.

For lunar missions, JPL suggests that the payload would track the moon in pitch and yaw, and the sun in roll. Sun orientation would be controlled by means of momentum-exchange servo motors. A solar cell would be placed on each of the four corners of the cell package, and their output compared. Any change in these outputs would cause a signal to be delivered to the brake of the appropriate motor - thereby causing the panel to assume the original angle with the sun.

Although the solar-cell sun-seeker roll-control system is believed to be relatively simple, JPL would prefer to eliminate it if at all possible to achieve maximum reliability.

Future Studies - A number of research and development programs are going forward in the solar cell area. Module development work has been accomplished, including short-circuit current-matching techniques for individual cells to achieve a maximum of 28-volt module efficiency. Encouraging work has been underway on epoxy mounting of solar cells on honeycomb or waffle-tapered beam reinforced structures. JPL also intends to evaluate the possibility of combining solar cells covering a thermoelectric semiconductor layer that will convert heat to additional electric energy.

- \* Electrochemical Batteries: In lunar and interplanetary probes, JPL suggests that injection-guidance power of 500 watts for 10 minutes be provided by manually activated silver-zinc batteries. Tests of a prototype indicate that a 500 watt battery will weigh six pounds and will have a rating of at least 19 watt-hours per pound under normal temperature conditions, decreasing to 17.3 after 24 hours at 130° F.

For a mission such as a "soft" Venus landing, nickel cadmium batteries floated across solar cells could be used to deliver a power pulse for information transmission. Battery would be charged prior to takeoff and would be recharged by solar cells or other means during flight. JPL believes that silver-zinc batteries, with the ability to go through one charge and discharge cycle reliably, appear to be most promising for this purpose.

- \* Thermoelectricity: JPL has surprisingly little to say about this type of power source other than to note that any heat supply which will heat the hot junction to the desired temperature may be used - including radioisotopes, reactors or solar energy.

\* Nuclear Power: JPL appears to place the most hope for future development on its work on the radioisotope thermionic diode or RTD, a heat-to-electricity energy conversion device. By utilizing the heat from a decaying fission-product radioisotope to heat the cathode, RTD can serve as a self-contained primary source of electrical power.

Ultimately, JPL envisions a unit the size of a large fountain pen capable of a power range of 8 to 15 watts per unit for a one-year period, depending upon the radioisotope used. Preliminary studies indicate that cerium-144 appears most promising and it may also be possible to use solar energy or a nuclear reactor as a heat source.

In preliminary tests, JPL used electrical heating instead of radioisotopes to demonstrate feasibility. An initial "thermoelectron engine" demonstrated that outputs of several integral watts at potentials in the range of 0.5 to 1.0 volts can be realized with cathode temperatures of approximately 1300° C. Work is going forward on an engine of new design.

\* Solid State Devices: JPL notes that static inverters of many different types have been developed utilizing germanium power transistors operating in a switching mode to convert nuclear and solar energy from unregulated dc power to regulated ac and dc power. At the same time, design and experimental work is underway to develop circuit techniques for utilizing solid-state devices in space power supplies. JPL believes that these advanced circuit-design techniques promise significant reductions in weight for both dc and ac sine-wave power supplies.

#### Proposed Space Program

JPL, in response to a request from NASA, has proposed a five-year "realistic" program of space exploration based on development of such booster rockets as the Vega, the advanced Vega or Centaur and the Army Ballistic Missile Agency Saturn. As previously reported (Science Trends Aug. 31, 1959) it is doubtful that all the interplanetary ventures proposed will follow the suggested time-table. However, the program is still under consideration.

Schedule: August, 1960 - A "moon miss" development test; October, 1960, a probe designed to bring 52 pounds of instruments within one million miles of Mars; January, 1961, an 82 pound payload including a vidicon system and passive radar in the far infrared launched in an escape toward Venus; June, 1961, the first "rough landing" of instruments on the lunar surface; Sept. 1961, high resolution photographic equipment and other instrumentation placed in a well-controlled orbit around the moon; Aug., 1962, a Venus satellite designed for low-resolution radar mapping, infrared surface photography and ionospheric sounding equipment designed to find a radio "window" in the atmosphere; August, 1962, a follow-up package designed for a "hard" landing on the surface of Venus; November, 1962, a Mars satellite similar to the Venus satellite; November, 1962, a follow-up Mars-Entry payload similar to that used for the Venus impact; February, 1963, a lunar orbit designed to return to a safe landing on Earth; June, 1963, a lunar soft-landing probe intended principally as a geological instrumented exploration of the moon's surface, and March, 1964, a mobile surface-exploration vehicle for a soft-landing on Venus.



### The Thermergistor - Low Energy Pulse-Measuring Device

Naval Ordnance Laboratory, Corona, Calif, has developed the "Thermergistor" - a device said to be capable of reliable measurements of energy pulses ranging from 10 to 200,000 ergs. The device has a number of developmental and test applications.

Description: The Thermergistor is basically a thermistor which has been placed in close contact with a heater of whatever impedance is desired. A low-impedance Thermergistor is constructed by winding a noninductive length of resistance wire about a thermistor. For higher impedances, a thermistor may be imbedded in a composition resistor.

Operation: An electrical pulse is dissipated in the heater of the Thermergistor so that the temperature of the heater rises. At the same time, the temperature of the heater-thermistor assembly rises to some equilibrium value - and then slowly drops as the heat energy is dissipated to the surroundings. The temperature rise changes the resistance of the thermistor and unbalances a bridge circuit. This, in turn, causes a small voltage change which is amplified and displayed on a galvanometer. The maximum rise thus registered is proportional to the energy of the electrical pulse.

Applications: Navy uses the lower energy ranges of the device to determine whether any energy pulses have unintentionally been introduced into firing circuits during switching operations or because of the collapse of nearby magnetic fields. Higher energy ranges are used to insure dependable firing when all conditions for detonation have been satisfied.

Evaluation of switching devices and changes due to temperature, humidity, shock and vibration or similar causes is said to be possible. The Thermergistor also indicates the effects of various types of corrective action which may include a different switch mechanism, better shielding or a spark-resisting device.

(For details see Navord Report 5950, Naval Ordnance Laboratory, Corona, Calif., or write OTS, U.S. Department of Commerce, Washington 25, D.C. for Report PB 151 686, 12 pages. 50 cents.)

### Heavy Water Research

Atomic Energy Commission has released for sale to the public and industry some 120 research reports and documents on the dual-temperature hydrogen exchange process for the production of deuterium, commonly called heavy water. Information was declassified in Dec. 1956, but has been held up until now by litigation.

(Readers may obtain further information, including a complete catalog of available reports, by writing Reports Branch, Div. of Information Services, Atomic Energy Commission, Washington 25, D.C. Ask for Rel. IN-14. 30 pages. Free.)

### RESEARCH CHECKLIST

- ( ) Hydrodynamic Noise - Navy Bureau of Ships is sponsoring research aimed at identification of noise sources as related to water flow. Movements of this sort can hydrodynamically excite vibration in hull plating and external appendages, it is reported, thereby generating radiated and self noise. Investigations are expected to lead to techniques for obtaining optimum desirable body shapes, surface roughness, construction materials and transducer location.
- ( ) Radiation Monitor - Oak Ridge National Laboratory has developed a new hand and foot radiation monitor (designated ORNL 1939) which is said to have a number of important advantages. Among these are simplified circuitry using glow transfer scaler tubes and electrical reset registers and high-reliability circuits utilizing silicon rectifiers, halogen-quenched stainless-wall G-M tubes and a regulated voltage supply.
- ( ) Hydraulic Mining - Bureau of Mines believes, after a literature survey of other nations, that hydraulic techniques may be applied successfully to many bituminous-coal deposits in the U.S. Technical literature indicates that Russian experience with this method has brought marked increases in productivity and recovery at lower costs.  
  
(Report available. 30 cents. Write Superintendent of Documents, Government Printing Office, Washington 25, D.C. for Bureau of Mines Inf. Circular, 7887 - Mining and Transporting Coal Underground by Hydraulic Methods)
- ( ) Electron Beam Magnetometer - A study by the National Bureau of Standards indicates that remarkably high sensitivity can be reached through an electron beam deflection method for detecting small magnetic fields. The system consisted basically of an electron gun, a long-focus lens and overlapping collector plates enclosed in a glass envelope which could be evacuated and sealed off from the pumping system.  
  
(Details available in Paper 63C1-8, National Bureau of Standards, Office of Technical Information, Washington 25, D.C.)
- ( ) Ground Effect Research - Studies by the U.S. David Taylor Model Basin have resulted in an approximate theoretical method for estimating power requirements for an annular jet vehicle operating on ground effect principles. Results indicate that in vehicles of less than 100 feet in diameter there is little load-carrying capacity, but as the size is increased potential payload and range becomes greater.  
  
(Report available. 28 pages. Microfilm, \$2.70. Photocopy, \$4.80. Order DTMB Aero Rept. 947 from Photoduplication Service, Library of Congress, Washington 25, D.C.)

### Publications Checklist

- ( ) Scientific Information, a Congressional report outlining some of the problems and progress in the field of the dissemination of scientific information. 12 pages. Free. (Write Committee on Science and Astronautics, New House Office Building, Washington 25, D.C. for Report No. 27.)
- ( ) Radioactive Waste Disposal, a summary-analysis of hearings before Congress on the problems involved in the disposal of radioactive waste from mining, milling and other industrial processes. 40 pages. Free. (Write Joint Committee on Atomic Energy, F-88, The Capitol, Washington 25, D.C. for Report - Industrial Radioactive Wastes.)
- ( ) Scientific Manpower, Congressional group, with some annoyance, takes a look at the lack of progress in the tabulation and study of scientific manpower by Federal agencies. 18 pages. Free. (Write Committee on Science and Astronautics, New House Office Building, Washington 25, D.C. for Report No. 28.)
- ( ) Freedom of Information, a progress report from Congress on censorship by Government agencies. Includes material on secrecy in Project Score, Air Force Missile Launching, Space Monkeys and similar affairs. 454 pages. Single copies free. (Write Subcommittee on Information, Committee on Government Operations, U.S. House of Representatives, George Washington Inn, Washington 25, D.C.)
- ( ) Coal Research, a report just published on research and related work on coal during 1956. 112 pages. Single copies free. (Write Publications-Distribution Section, Bureau of Mines, 4800 Forbes Avenue. Pittsburgh 13, Pa. for Inf. Circular 7904)
- ( ) Molten Salts, a bibliography prepared at Rensselaer Polytechnic Institute based on a survey of the information published up to 1958 in the technical press on the subject of molten salts. A valuable research aid in this field. 73 pages. \$2. (Order PB 151 429 from OTS, U.S. Department of Commerce, Washington 25, D.C.)
- ( ) Doppler Tracking, a description of the theoretical development and some experimental results of a Doppler tracking program for earth satellites. Discusses limitations of this method and includes a detailed outline of the program. 26 pages. Single copies free. (Write Technical Information -BID, National Aeronautics and Space Administration, Washington 25, D.C. for Pub. N-73321)
- ( ) Industrial Laboratories, a brief but informative guide on the question of establishing a laboratory for research and quality control in small plants. Includes suggestions for obtaining further information. 4 pages. Single copies free. (Write Service Department, Washington Science Trends, 1120 National Press Bldg., Washington 4, D.C.)
- ( ) Outer Space Propulsion by Nuclear Energy, copies are once again available of this transcript of testimony by witnesses from Government agencies and laboratories on such subjects as the nuclear rocket program, nuclear ramjets, auxiliary atomic power and similar matters. 232 pages. 60 cents. (Write Superintendent of Documents, Government Printing Office, Washington 25, D.C. for Pub. NO. Y 4.At7/2:Sp 1)

